

# Jlab cavity design concepts

R. Rimmer et. al.

Project X collaboration meeting

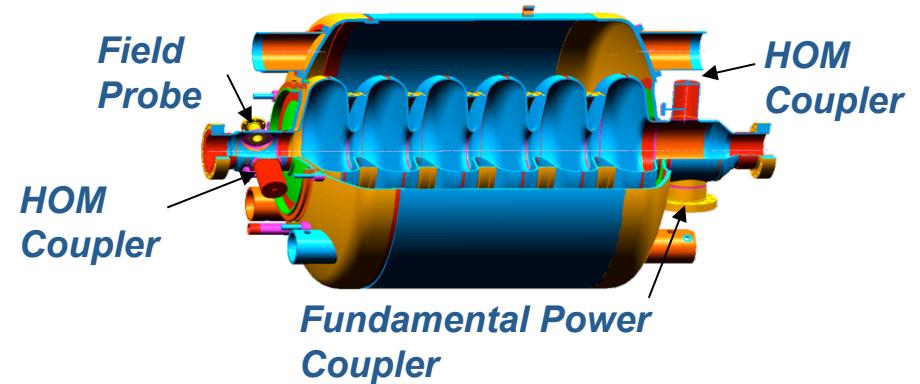
Sept. 8, 2010

# outline

- Jlab background and experience
- Jlab FY10 proposal
  - 1-cell prototypes
  - CM design study based on SNS
- Jlab FY11 proposal
  - Multi-cell prototypes
  - Process improvement studies (Vertical EP)
- Long-range capabilities
  - Capacity in TEDF
  - Synergy with other programs
- Conclusions

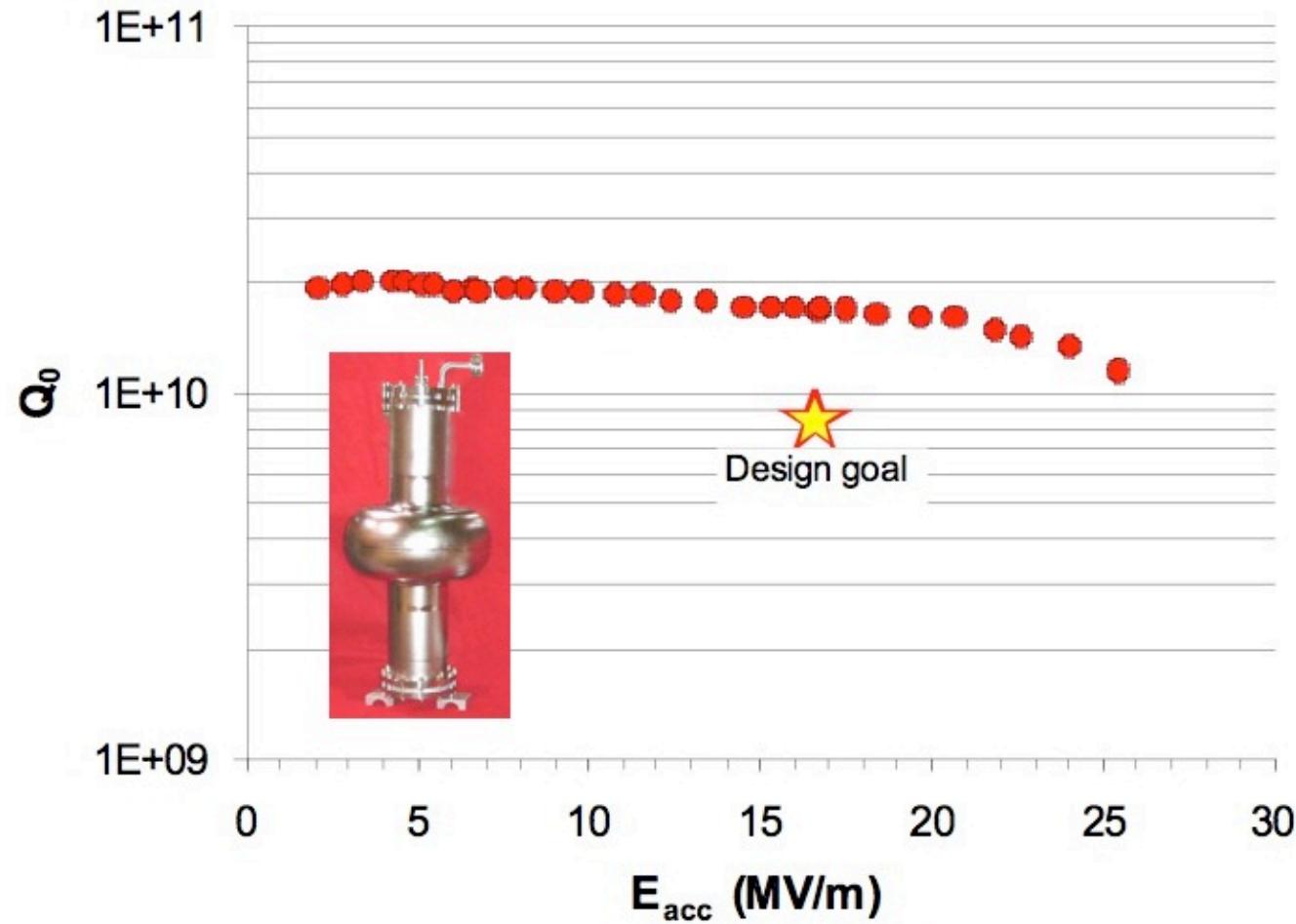
# JLab experience

- APT prototypes etc.
- SNS cavity & cryomodule R&D
- SNS cavity production
- SNS cryomodule production
- 750 MHz high-current cavity for FEL
  - 1-cell bare cavity
  - 5-cell with waveguides



VTA Test Results  
- single cell 750 MHz ( $\beta = 1$ ) -

- Encouraging results on single cell



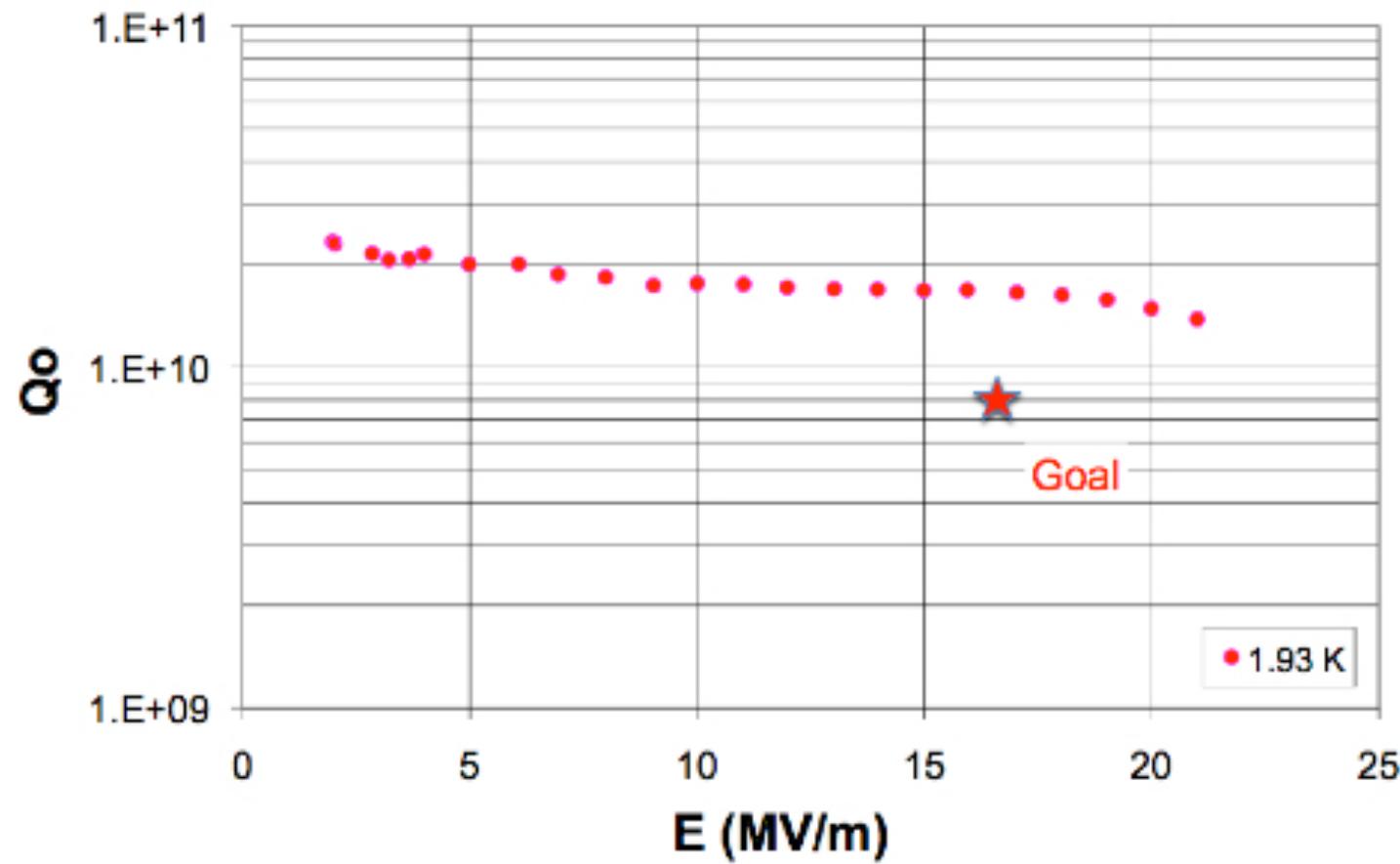
VTA test results for a single cell 750 MHz  $\beta = 1$  cavity

## Five-cell 750 MHz Prototypes ( $\beta = 1$ ) -



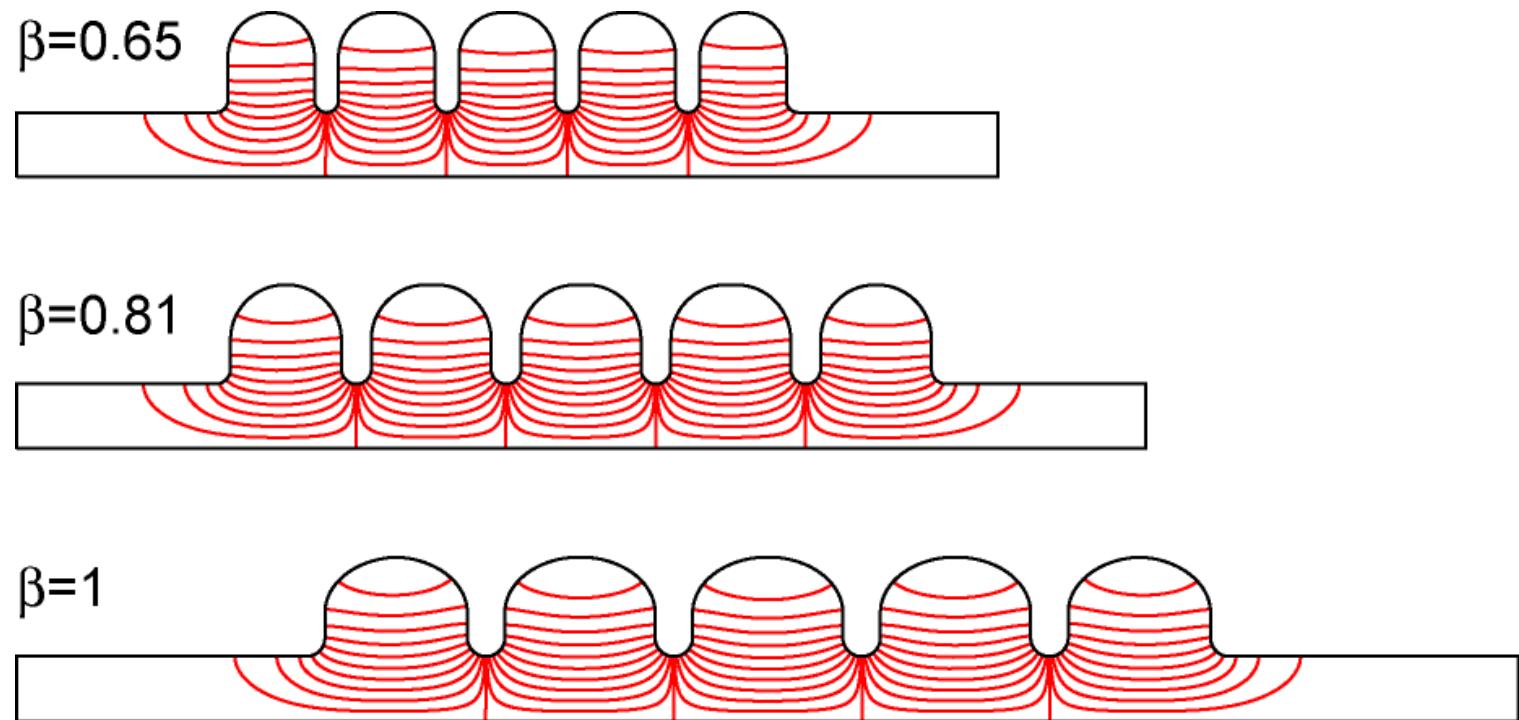
Five-cell 750 MHz  $\beta = 1$  cavity

# 748.5 MHz HC 5-cell first test, BCP only, no outgas



# A Family of L-band SRF Cavities for High Power Proton Driver Applications

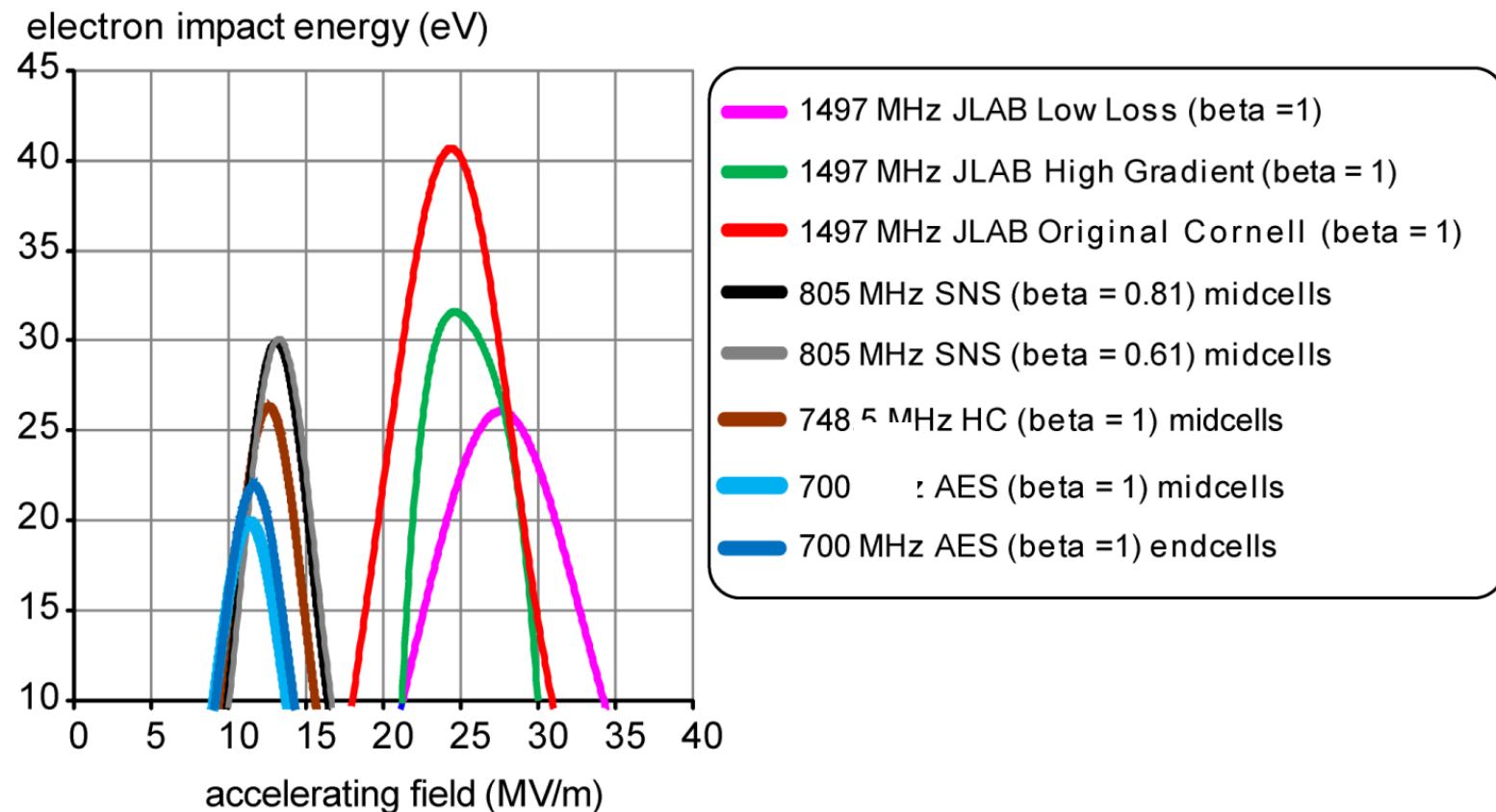
R.Rimmer, F. Marhauser, PAC '09



Cavity profiles and fields from Superfish

# Multipacting Analysis

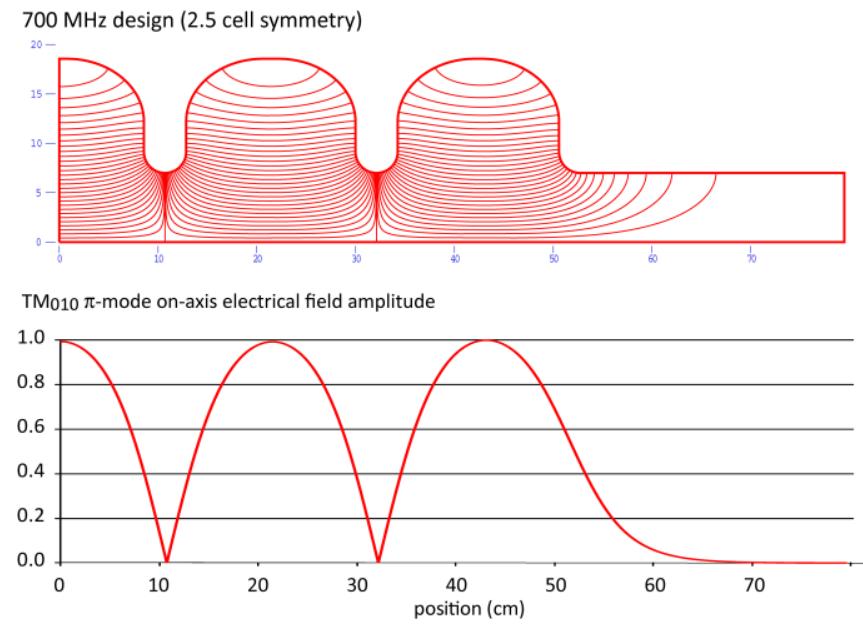
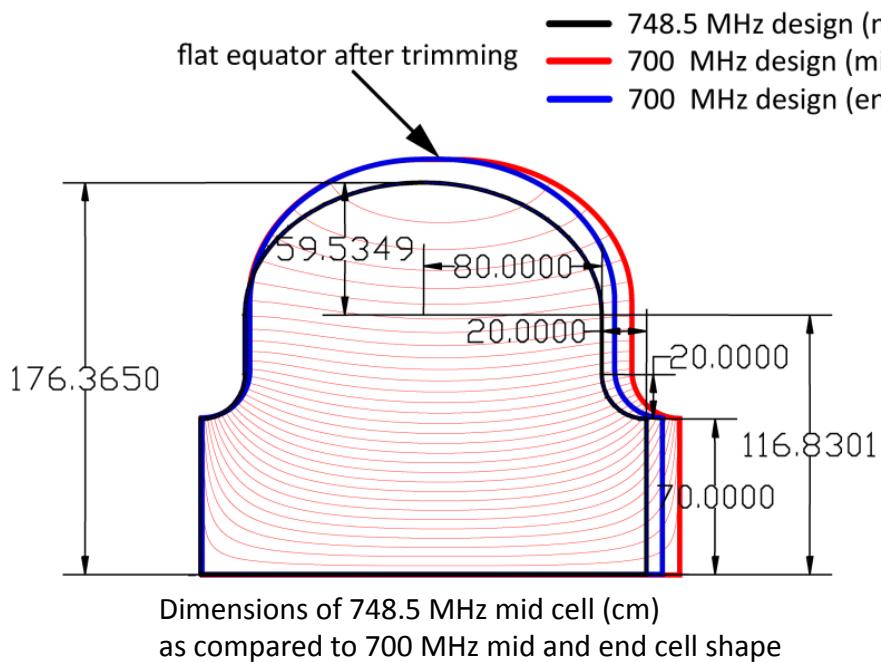
## □ Earlier Studies: Scaled HC design to 700 MHz



2D Fishpact multipacting simulation for different cavity designs

# Cavity Scaling Methodology (Marhauser)

- 1) Keep beam tube diameter fixed
- 2) Scale existing HC cell shape by geometrical factor 748.5MHz/XYZ MHz elsewhere
- 3) Cell length is  $\beta\lambda/2$  for mid cell
- 4) Choose relatively long flat equator for mid cell to aim for **single die design**
- 5) End-cells can be trimmed without cutting away from elliptical shape → provides weld on flat joints (could not be achieved for our original 750 MHz cavity, trimming was too large)
- 6) Tune mid cell equator radius to obtain frequency
- 7) Join to end cell and trim end cell equator region to tune field flat → changes frequency
- 8) Re-tune equator radius of end & mid cells to tune **both** frequency and field flatness



2D 700 MHz cavity design tuned field flat

# Comparison of cavity shapes

Haipeng Wang, Frank Marhauser

Frequency MHz	$\beta=v/c$	Iris r/ $\lambda$	R/(Q* $\beta^2$ )/cell $\Omega/\text{cell}$	Epaek/Eacc mT/(MV/m)	Beak/Eacc mT/(MV/m)	G $\Omega$	R/(Q $\beta^2$ )*G/cell [ $\Omega^2/\text{cell}$ ]	cell no.	Equator R/ $\lambda$	kcc %	N <sup>2</sup> /( $\beta$ kcc)	Name ID
700	0.82	0.187	77.6	2.48	6.1	213	13333	5	0.4693	4.41	691	APT-new
700	0.64	0.152	82.3	2.94	7.1	162	22375	5	0.4656	3.02	1293	APT-new
805	0.61	0.115	125	2.71	5.72	179	31902	6	0.4397	1.53	3857	SNS-med
805	0.81	0.131	122.7	2.19	4.72	260	16500	6	0.4403	1.52	2924	SNS-high
805	0.47	0.104	120.7	3.41	6.9	136.7	24801	6	0.464	1.50	5106	RIA
700	0.47	0.093	156.2	3.57	5.88	148.1	23133	5	0.4367	1.35	3940	TRASCO
1497	1	0.175	96	2.56	4.56	273.8	31077	5	0.4678	3.29	1489	JLab-OC
1300	1	0.152	115.1	2	4.26	270	29709	9	0.4479	1.87	4332	TESLA
1497	1	0.153	111.9	1.89	4.26	265.5	36103	7	0.4514	1.72	2849	JLab-HG
1497	1	0.132	128.8	2.17	3.74	280.3	17865	7	0.4337	1.49	3286	JLab-LL
704	1	0.200	79.4	1.99	5.82	225	35250	5	0.491	3.16	791	BNL-AES
1300	1	0.152	126.8	2.19	3.78	278	37971	8	0.4281	2.38	2689	ILC-RE
1300	1	0.130	133.7	2.36	3.61	284	50268	9	0.4276	1.52	5329	ILC-LL
748.5	1	0.175	101.4	2.91	4.14	291.1	29518	5	0.442	4.20	595	JLab-HC
Fermi												
650	0.61	0.090	203.2	2.26	4.21	191	38811	5	0.423	0.75	5464	Project-X
650	0.90	0.108	157.5	2.00	3.75	255	40163	5	0.434	?	?	Project-X
JLAB												
650	0.9	0.108	158.64	2.35	3.98	247	39262	5	0.421	0.55	5050	Project-X
650	0.9	0.152	119.36	2.54	4.37	251	29921	5	0.433	2.18	1274	Project-X
	1	0.000	195.9	1.571	3.05	256.6	50268		0.3828	0.00		Pillbox

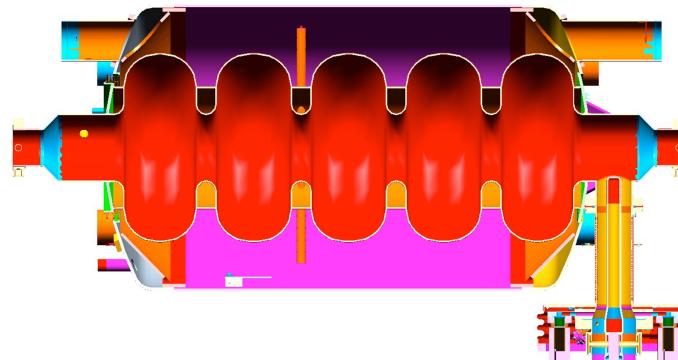
# Jlab FY10 proposal

- Shape optimization
  - Meet PX Functional requirements
- 1-cell prototypes
- CM design study based on SNS
  - Try to fit draft lattice spacing
  - Estimate overhead for segmentation

Status: funds pending

# Jlab FY11 proposal

- 650 MHz Multi-cell prototypes
- Process improvement studies (Vertical EP, ICP, etc)
  - Many unanswered questions from SNS
- Develop draft production plan
- Evaluate multi-spokes to replace some of SSR2's?
- Look at spoke cryomodule concepts



# Long-range capabilities

- Capacity in TEDF
  - Planning to 2 CM/month max capacity
  - 16 multi-cell cavities per month + R&D
- Synergy with other programs
  - ESS/SPL, SNS PUP, etc.
- Jlab would like to develop and supply the 650 MHz cryomodules as our contribution (happy to work with Industry, India et. al.)
- Jlab could also provide some of the spoke cryomodules

# Capacity in TEDF era.

- Production capacity equivalent to:
  - 2 cryomodules per month
  - 16 multi-cell cavities per month
- Comparable to CEBAF days with more complicated processes
- Able to support multiple DOE projects and R&D in parallel
- Ideal for training next generation of staff & university/industry partners
- Funds/effort available for commissioning in FY12, FY13.
- Constant effort funding supports basic operations, [build out will come from projects](#)



# SRF Facilities in TEDF Project

Advanced Conceptual Design

Cavity and cryomodule cryo/RF testing

Cryomodule assembly

Chemistry, cavity treatments, and support areas

Cleanroom

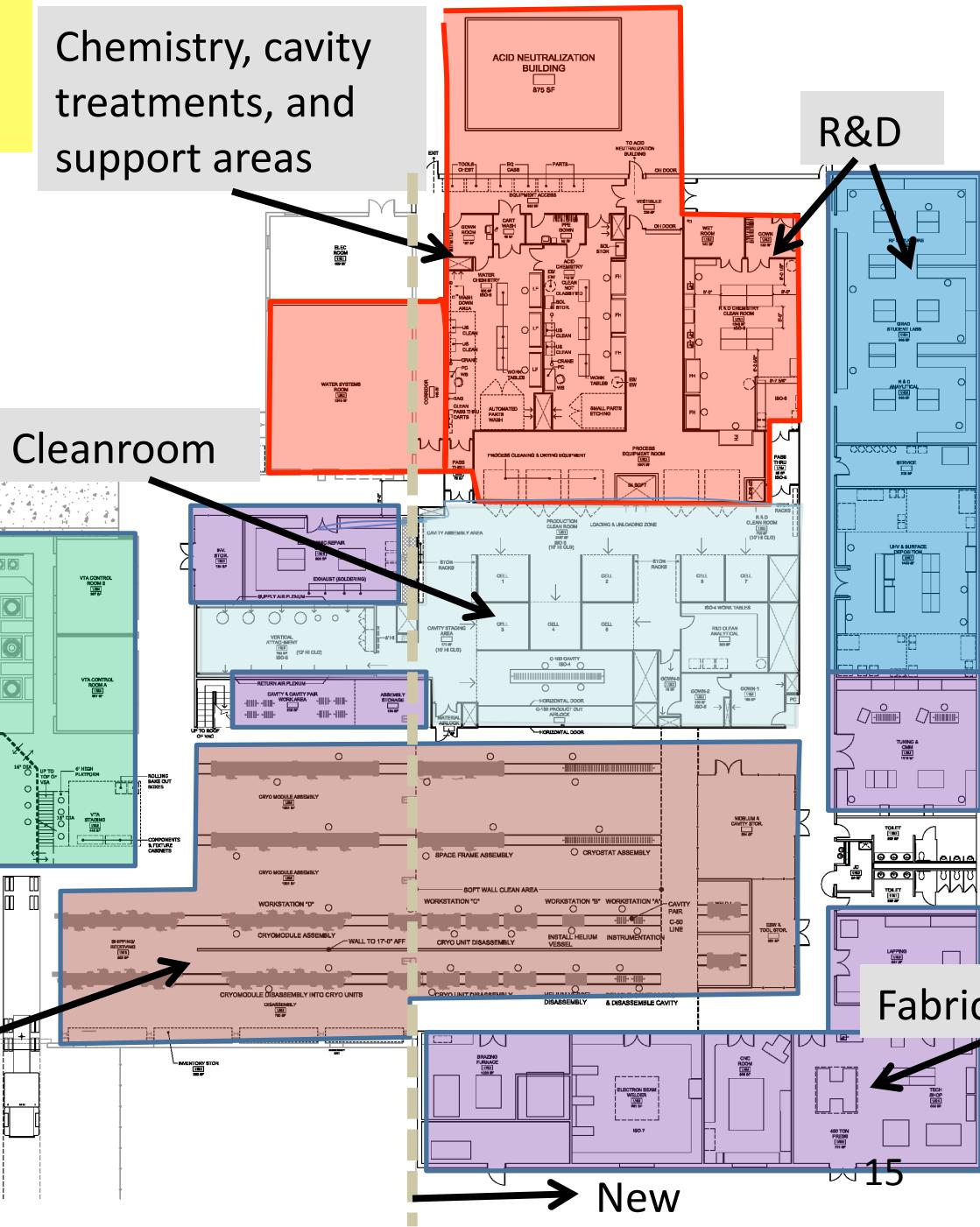
R&D

15

*Renovation and Addition - First Floor*

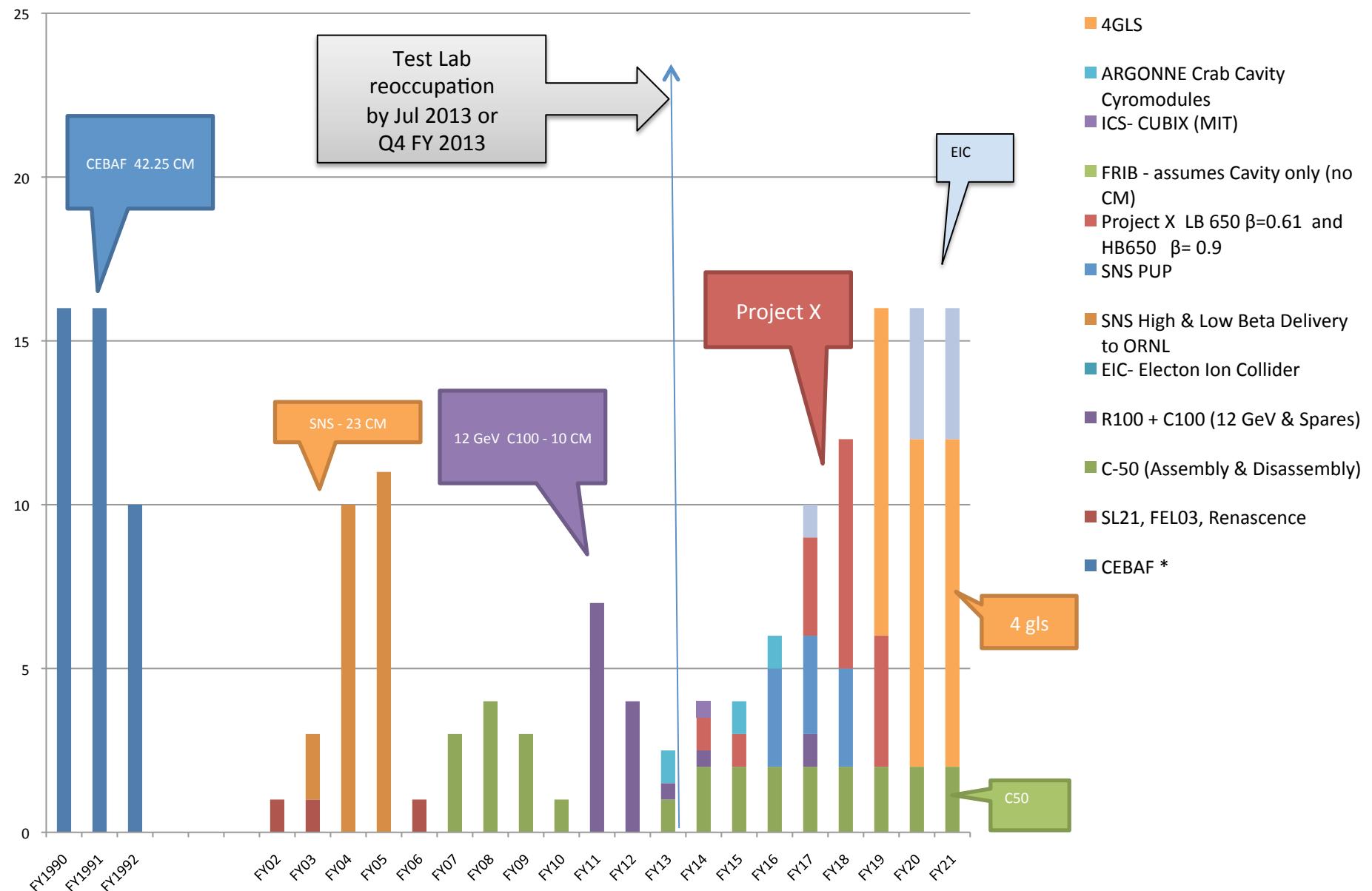
*Build*

*Jefferson Lab  
Scale: 1/8 = 1'-0"*



# DRAFT SRF Forecast Cryomodules 28Jun2010

Data prior to 2009 may be incomplete



# Conclusions

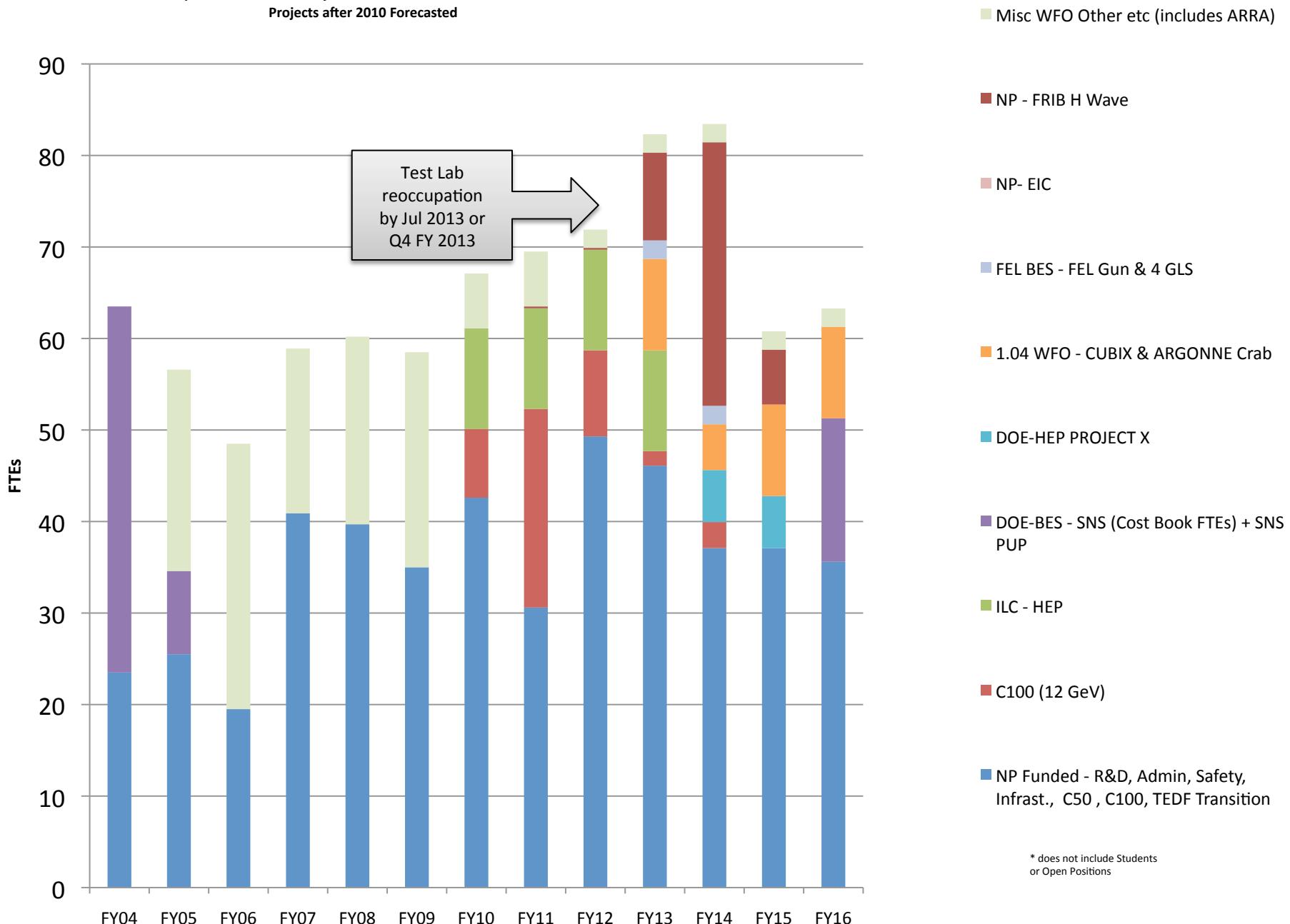
- Jlab experience highly relevant to Project X
- Jlab would like to provide the 650 MHz modules
  - happy to work with industry, India etc.
- Spoke Cryomodules are still of interest
- TEDF facility will be online and available
- Jlab team enthusiastic to support R&D effort starting now

Back up

## DETAIL - SRF Total FTEs- Forecast by Funding

Data prior to 2010 from Project Cost Book and Totals in "Cost Point"

Projects after 2010 Forecasted



# Provocative questions

- TSR's or DSR's instead of SSR2's
- 100mm bore through SSR/TSR's?
- 487.5 MHz section? (if 162.5 MHz in RFQ?)
- 650 MHz (or 812.5) MHz beta=1?
- Can lattice be adjusted to fit cryomodule spacing?
- Can the linac be fully segmented (yes!)